ODONATA COLLECTED AND OBSERVED IN 1945 AT TWO ARTIFICIAL PONDS AT UPTON, NEW JERSEY.

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During the Spring and Summer of 1945, the writer often collected insects of various orders in the Pine-barren region of New Jersey. On seven different days between May 20 and August 12, dragonflies were collected at two ponds near Upton station on the Pennsylvania Railroad, Long Branch Division. All of the thirty-six species in the following list were actually captured or unmistakably recognized over the water or banks of the ponds. In the same neighborhood many interesting species have been taken, some within a few hundred yards and others as much as three miles away. These include *Progomphus obscurus, Gomphaeschna furcillata, Cordulegaster maculatus, Tetragoneuria semiaquea, Dorocordulia lepida, Libellula flavida, Agrion apicale,* and *Nehalennia gracilis.* They are not included, however, since they do not form part of the immediate fauna of the ponds themselves. Records of their occurrence and notes on their ecology are being published elsewhere.

The two ponds at Upton were created in 1931 when sand was excavated to build the approaches of a highway bridge across the railway, and are very close to both the railway and the heavily travelled highway. Their combined area, including the narrow sandy strip separating them, is about seven acres and they vary in depth from one to six feet. The smaller pond is fed by springs near its center and the larger one by seepage from an adjoining cedar swamp. The water of the latter pond is the color of strong tea and the entire pond is of quite different character than the smaller spring-fed one. It contains no submerged vegetation and very few emergent plants, while the banks are overgrown with *Kalmia, Vaccinium,* and similar woody shrubs. On the other hand, the smaller pond is fairly choked with submerged and, in the shallow portions, emergent vegetation and the banks are grassy. The bottoms of both are of white sand and small pebbles and there are narrow sandy beaches at various points about their periphery. Since some of the following species display a marked preference for one pond or the other, the designation "cedar pond" and "clear pond" will be used to indicate the immediate environment of such species. Other dragonflies were found only or chiefly in parts of the area between the ponds which were flooded by water from the cedar pond. Here were grasses, sedges, cranberry, *Smilax, Kalmia,*

Vaccinium, small oaks and pines, growing in water from four to twelve inches deep. These places cannot be considered as part of the pond since their vegetation is exactly the same as that of all the dry land nearby. In the protection of this vegetation such delicate species as *Nannothemis bella, Nehalennia integricollis,* and *Anomalagrion hastatum* were found, and one species *Libellula semifasciata* was seen nowhere else.

On some visits, only a few hours in the forenoon were spent at the ponds, while on other dates they were also thoroughly searched in the afternoon.

In parentheses, following the name of each collected species, have been entered the specimens actually collected by the writer. In the case of the Anisoptera, these data cannot be considered an index to the abundance of a species because some, like *Anax longipes, Libellula auripennis,* and *Tramea carolina* proved difficult to catch, and others, such as *Anax junius, Libellula pulchella,* and *Sympetrum vicinum* were of little interest to the collector. However, in the Zygoptera, especially the genus *Enallagma,* the number of specimens collected is an accurate indication of the absolute and relative abundance of the various species.

Gomphus exilis Selys (1♀—24.VI; 1♂—30.VI; 1♀—8.VII). These specimens, measuring respectively 35, 37, and 36 mm. in total length, are much smaller than examples of the same species taken near a stream a few miles away. The first ♀ was taken as it hovered over the grassy bank of the clear pond and on the same day a ♂ was seen resting on a floating timber. The other two specimens were secured when they were found squatting on the sandy beaches of the cedar pond. These four individuals were the only ones seen.

Anax junius Drury. This species was noted frequently throughout the season. Coupled pairs were often seen ovipositing as they perched on emergent grasses.

Anax longipes Hagen (1♂—24.VI; 1♂—29.VI; 1♂—30.VI; 1♂—8.VII). *Longipes* was surprisingly abundant on some days, sometimes far exceeding *junius* in point of numbers. It was seen in greatest numbers on 29.VI when it was noted that only *C. elisa, C. martha, P. longipennis,* and *T. carolina,* among the Anisoptera, were more numerous. On this date, two unattached ♀'s were seen ovipositing in shallow water. One was unattended and the second had several ♂'s hovering over her for a moment, but they disappeared before she had finished her

task. Each ♀ clung to floating plants and curved the distal half of her abdomen into water in the same manner as *junius*. The species was seen also on 22.VII and on 12.VIII.

Nannothemis bella Uhler (4♂—24.VI; 2♂—29.VI; 4♂—8.VII). Taken at the edges of both ponds where tall grasses and sedges offered concealment. No ♀'s were seen.

Perithemis domita Drury. One ♂ was seen at the cedar pond on 12.VIII.

Celithemis elisa Hagen (3♂, 2♀—24.VI; 3♂, 2♀—29.VI; 2♂, 1♀—30.VI; 4♂—8.VII; 2♂, 2♀—22.VII; 2♂—12.VIII. Very abundant on every visit except 20.V, when it was not seen. On 29.VI, it was emerging in large numbers at the clear pond and ovipositing pairs were common everywhere.

Celithemis martha Williamson (5♂, 1♀—24.VI; 3♂, 1♀—29.VI; 2♂, pr. in cop.—30.VI; 8♂, 4♀—8.VII; 2♂—22.VII; 5♂—12.VIII). This species was found to be just as abundant as *C. elisa* on every occasion. Teneral ♂'s have never been seen. Indeed, most of the ♂'s collected, even on the earliest dates, appeared to be quite old, while most of the ♀'s were teneral. The only old ♀'s taken were in cop. with ♂'s. As late as 12.VIII, teneral ♀'s were very abundant at nine o'clock in the morning but were not seen later in the day.

Celithemis ornata Rambur (1♀—29.VI). This species, not previously known from any state north of North Carolina, is evidently a stray and not part of the normal fauna. What is presumed to have been the same individual was seen on 24.VI and was noted then to be very old. On both dates, *ornata* flew among the emergent plants in a shallow bay of the clear pond.

Erythrodiplax berenice Drury (1♂—22.VII). This single individual is probably a wanderer from its normal habitat in the brackish coastal marshes.

Libellula deplanata Rambur. A few of this species were seen at the ponds in June. It was abundant at other smaller ponds and ditches nearby.

Libellula auripennis Burmeister (1♀—29.VI). This was seen also on 24.VI, 30.VI, and 12.VIII. On the two latter dates, ♂'s were seen in considerable numbers, but were extremely difficult to capture. In the flooded area between the ponds it was most abundant, flying with *L. semifasciata* and showing great activity.

Libellula semifasciata Burmeister. Seen only in the grassy flooded

area between the ponds, where it occurred in considerable numbers, on 29.VI, 30.VI, 8.VII, and 12.VIII. Its numbers were not at all diminished on the latter date.

Libellula pulchella Drury. This species was seen in small numbers about both ponds on most occasions when they were visited. It was more abundant on later dates.

Libellula incesta Hagen (1♂—30.VI). This individual was the only one of the species which has been seen. It was flying with *P. longipennis* and perching on the tips of bare branches of bushes only a few feet from the highway. *Longipennis* repeatedly drove *incesta* from its perch.

Libellula lydia Drury. Only one or two individuals of this omnipresent species have been seen at the Upton ponds.

Sympetrum vicinum Hagen. Although seen nearby on 22.VII, this species was not seen at the ponds until 12.VIII, when it occurred in swarms about *Vaccinium* bushes growing in the water at the eldge of the cedar pond. All of those examined were teneral or juvenile but were flying about quite energetically. Many scattered individuals were seen everywhere about the ponds and throughout the pine woods, where mature specimens were taken.

Leucorrhinia intacta Hagen. A single individual was seen at the cedar pond on 24.VI.

Leucorrhinia frigida Hagen (1♂—24.VI). This is the southernmost outpost of this characteristically northern species which flew with *P. longipennis* among the emergent plants in a shallow bay of the clear pond. Its flight was much weaker than that of *intacta*.

Pachydiplax longipennis Burmeister (2♂—8.VII; 1♀—12.VIII). Always one of the most abundant of the Anisoptera, *longipennis* proved to be thoroughly annoying to the collector because of its presence everywhere and because it frequently darted at, and drove away, resting dragonflies just as the net-stroke was to be made to capture them. Exceedingly abundant during June, this species decreased in numbers during July and was seen only in small numbers in August.

Erythemis simplicicollis Say (2♂, 1♀—8.VII). Seen also on 29, 30.VI, 22.VII, and 12.VIII, but never in large numbers. It occurred only in the flooded grassy area between the ponds, where it flew close to the ground or water with a slow hovering flight with occasional quick darts.

Pantala flavescens Fabricius (1♂—24.VI). Another was seen on 24.VI.

Tramea carolina Linnaeus (1♂—20.V; 2♂—29.VI; 1♂—12.VIII). This species was seen on every visit from 20.V and was very abundant on 24.VI, 29, 30.VI, 8.VII, and 22.VII. On 29, 30.VIII, ovipositing pairs were common, the ♂ usually releasing the ♀ during the actual egg-laying and again seizing her when she rose from the water. On 12.VIII, the species was seen in much smaller numbers.

Lestes forcipatus Rambur. A single ♂ of this species was taken on 24.VI at the clear pond by my companion, Mr. John Gillespie.

Lestes vigilax Hagen (3♂, 1♀—24.VI; 6♂, 1♀—29.VI; 7♂—30.VI; 4♂, 2♀—8.VII; 1♀—22.VII; 2♂, 3 prs. in cop.—12.VIII). This species is one of the commonest of the Zygoptera at Upton. In June and early July, it was exceeded only by *Enallagma pictum,* but on 12.VIII, when *pictum* had almost disappeared, *vigilax* was more abundant than ever before, many coupled pairs being seen at both ponds, but more commonly at the cedar pond.

Argia violacea Hagen (2♂—24.VI; 2♂—29, 30.VI; 7♂—8.VII; 1♂—22.VII; 1♂—12.VIII). This species was quite common about *Kalmia* bushes at the edge of the cedar pond, but there was no trace of it at the clear pond on any occasion, nor were any ♀'s seen.

Nehalennia integricollis Calvert (1♂—12.VIII). The only one of this species which has been seen flew very delicately below the tops of the grasses in the flooded area between the ponds.

Enallagma divagans Selys (1♂—24.VI). This is the only specimen of *divagans* which has been collected at the ponds. It was taken in a shallow bay of the clear pond where there is much emergent vegetation.

Enallagma recurvatum Davis. A single ♂ which has been identified as this species was collected by Mr. John Gillespie on 24.VI.

Enallagma pictum Morse (4♂, 11♀—24.VI; 4♂, 8♀—29.VI; 5♂, 6♀—30.VI; 1♂, 1 pr. in cop.—8.VII; 1♂—12.VIII). In late June and early July, *pictum* was the most abundant of the Zygoptera, if not the most abundant dragonfly, but decreased sharply in numbers after 8.VII. It was found in greatest abundance about the emergent vegetation of the clear pond.

Enallagma doubledayi Selys (1♂—24.VI; 2♂—29.VI; 5♂—8.VII; 1♂—12.VIII). This species occurred chiefly at the cedar pond and flew in close association with *E. civile, E. aspersum,*

and *L. vigilax*. With the two former species, it flew close to the water's surface and alighted on the emergent plants very close to the water. It was extremely active and wary. Three ♀'s taken on 24.VI and one ♀ taken on 8.VII probably belong to this species or the following.

Enallagma civile Hagen (1♂—22.VII; 1♂—12.VIII). This species has been taken at both ponds but is quite rare. At the cedar pond it flies with *E. doubledayi,* from which is cannot be distinguished on the wing.

Enallagma aspersum Hagen (2♂—29, 30.VI; 7♂—8.VII; 11♂—12.VIII). Except for *E. pictum,* this is the commonest *Enallagma,* and on 12.VIII, when *pictum* was very scarce, *aspersum* had reached its peak abundance. This species flies and alights less than an inch from the surface of the water. If disturbed while at rest, it often dashes far out over the water, seeming to be skating on the surface, and sometimes dipping into the water. It has been taken at both ponds but is decidedly more abundant at the cedar pond where it frequents large patches of open water where there are a few grass-stems to alight upon.

Enallagma traviatum Selys (1♂—29.VI). Except for another ♂ collected by Mr. Gillespie on 24.VI, only this single specimen of *traviatum* has been taken. ♀'s of this and the preceding three species of *Enallagma* have not been met with, except as noted under *E. doubledayi.*

Ischnura posita Hagen (1♂—24.VI). Seen only occasionally at the ponds, though frequently collected nearby.

Ischnura verticalis Say (6♂, 8♀—20.V; 1♂—24.VI; 2♂, 1♀—29, 30.VI; 1♂—8.VII; 1♀—22.VII; 1♂, 2♀—12.VIII). This species was very abundant on 20.V and has since been seen in greater or lesser numbers. On 12.VIII, it was decidedly scarce, only three or four individuals of each sex being noted.

Anomalagrion hastatum Say (6♂, 7♀—24.VI; 2♂, 5♀, 1 pr. in cop. 29, 30.VI; 3♂, 7♀—8.VII; 2♂, 1♀—22.VII; 13♂—12.VIII). On 24.VI and 29, 30.VI, ♀'s of this species were much more abundant than the ♂'s. On 12.VIII, ♂'s, most of them teneral, were extremely numerous everywhere. Only one coupled pair of this species has been taken. The ♂'s evidently become more abundant late in the afternoon, as nearly all of those collected on 12.VIII were taken at about six o'clock. They fly throughout the day, however, and two ♂'s were taken at 7:30 in the morning on 30.VI.

From the foregoing notes many conclusions may be drawn, though few of them are of great significance. Only continued study over a period of years, from beginning to end of the dragonfly season, including the larval as well as the adult stages, can be the basis of valid general conclusions on the ecology of any population of these insects. However, the following conclusions, based as they are upon the facts here presented, may be of some interest.

1. The odonate fauna of the ponds can be divided into two groups, one containing the larger anisopterous species with considerable powers of sustained flight, and the other including the small, delicate Anisoptera such as *Nannothemis bella* and all of the Zygoptera. It is natural that members of the first group should soon take up residence in a newly-created pond, but the presence of members of the other group is less easily explained. A rather thorough reconnaissance of the surrounding territory disclosed no nearby habitat suitable to even a small percentage of the species in the second group. Along nearby cedar streams, *Argia violacea* was found, while *Nannothemis bella, Lestes vigilax, Enallagma pictum, Ischnura posita* and *verticalis,* and *Anomalagrion hastatum* were found in and near cranberry bogs about three miles away. The other Zygoptera were found nowhere in the immediate territory except at the two Upton ponds. Although some species show certain migratory tendencies, it is not likely that all the species of the second group flew, of their own volition, through three or more miles of dense pine woods to take up residence at the ponds, nor is it likely that their larvae were carried there by watercourses since the ponds are not fed by streams and most of the species in question are considered pond insects. The logical explanation is that either fertilized females or individuals of both sexes of each species were carried from greater or lesser distances by strong winds, to the pond or its immediate vicinity. Some of the species, such as *Celithemis ornata, Erythrodiplax berenice, Leucorrhinia frigida,* and *Enallagma traviatum* may have been carried for very great distances and may possibly represent new arrivals of this season. Other species have doubtless been there since shortly after the ponds were created. Still others may have arrived in the past and failed to establish themselves. The conclusion, then, is that most dragonfly populations are constantly changing. While some species become extinct, wind-borne dragonflies are continually arriving, some establishing themselves more or less permanently and others finding the environment unsuitable. The wind, therefore, is one of the most influential factors affecting dragonfly populations.

2. Since the two ponds are of quite different character, it is logical that each should have its characteristic dragonflies. The *Anaces, Celithemi,* and *Tramea* flew in great numbers about all parts of the clear pond, while *Argia* and most of the *Enallagmae,* except for *pictum,* were found commonly at the cedar pond and often not elsewhere. Many of the other species occur at both ponds but in sharply differing degrees of abundance. Here it is possible that the pond containing decidedly smaller numbers of such a species has simply received the overflow or the wanderers from the other pond. Still other species occur chiefly in the flooded grassy area between the ponds and one of these, *L. semifasciata,* has not been seen elsewhere. In every case, the number of individuals of all species combined, occurring at a given point in either pond, varied inversely as the distance of that point from the other pond. In a shallow, weedy bay of the clear pond, the nearest point to the cedar pond, and in the flooded area between the ponds, the dragonfly population reached its greatest development, both in numbers and species. Here, too, occurred all of the species which were not generally distributed about either pond. These facts demonstrate the rule that in habitats where a variety of environmental features exist, the largest number of species and individuals occur where the greatest number of these features appear close together or in combination.

3. At the Upton ponds, a combination of conditions exists which is particularly favorable to the existence of several species of dragonflies which have not been found elsewhere in New Jersey in such great numbers. For example: during the summer of 1930, before these ponds existed, B. E. Montgomery collected extensively in southern New Jersey, but found only one individual of *Celithemis martha.* At the ponds, it was so abundant that the number of specimens collected, thirty-three, conveys no idea of how many were seen. Specialized collecting could have procured a hundred or more on many days. In the literature, there is no record of *Anax longipes* being seen or collected in very large numbers in the United States. On a single day at Upton, at least twenty different individuals of *longipes* have been seen. This is a conservative figure. From this evidence it is logical to conclude that the environment offered by the ponds at Upton is unusually favorable to dragonflies. That many additional species will be found there is not unreasonable to expect.

4. Southern New Jersey, below the fall line, has long been recognized as the meeting place of northern and southern animals and

plants. Though the flora seems predominantly southern, many plants of the Transition and Canadian Life Zones persist as far south as Cape May, which is considered the northernmost outpost of the Lower Carolinian Life Zone. Only in such a region as this could *Celithemis ornata* and *Leucorrhinia frigida* be found side by side, or *Dorocordulia lepida* of the north be found flying with the southern *Libellula deplanata.* Only the unusual character of the region can explain this odd juxtaposition of northern and southern species.

5. Though it is the usual habit of dragonflies to quit their aquatic habitat as soon as they are able to fly, and seek the protection of wooded areas until their chitinization is complete, *Sympetrum vicinum* remains close to the ponds during its teneral life and then flies to the adjoining woods when mature. This habit has been noted elsewhere for this and other *Sympetra,* and it is doubtless displayed by certain other dragonflies.

6. Time of day has an important influence upon the emergence of dragonflies. Between seven and ten o'clock in the morning, various species, including *Celithemis elisa* and *martha* (♀), *Pachydiplax longipennis, Enallagma pictum,* and *Anomalagrion hastatum,* were found emerging, often in great numbers. By noon, most of the tenerals had disappeared from the banks of the ponds and the only trace of the mass emergence is the dead and dying dragonflies at the water's edge which encountered obstacles to their ecdyses. Most of the teneral Zygoptera do not stray far from the water, but conceal themselves as well as they can in the vegetation of the banks. These are often stirred up by the collector soon after emergence, but they are not normally on the wing as tenerals, in marked contrast to most of the Anisoptera.

7. The flight of mature dragonflies also is influenced greatly by the hour of the day as well as the familiar factors of temperature, sunshine, and amount of wind. Many species were found to be most active and abundant in the forenoon, while others appeared in largest numbers later in the day and often remained on the wing until evening. The first category includes *Anax longipes,* the *Celithemi,* most of the *Libellulae,* and *Tramea carolina.* The second group is composed chiefly of the Zygoptera. In the case of some species, especially *Celithemis elisa* and *martha,* many single males were noted quite early in the morning, but ovipositing pairs were not seen until several hours later. This indicates that in some cases the males are on the wing earlier than the females, or that the females show no predisposition to copulate at so early an hour.

The teneral females seen early in the day do not enter into this question since every female which has yet been taken in coitu was thoroughly mature. As a general rule, copulation and oviposition takes place largely during the midday hours.

8. The sex of dragonflies is more or less connected with their seasonal distribution. For instance, periods of great abundance of *Anomalagrion hastatum* have been noted for each sex, but these periods fail to coincide. In the case of *Celithemis martha,* teneral females have been seen in almost equal numbers throughout the season, while no teneral males have been seen. This indicates either that the general emergence-period of the males was very early in the season or that the males and females both emerge throughout the season and the teneral males manage to conceal themselves better than the females. The facts point to the first conclusion since the average run of males captured has been older and older as the season progressed, while the average females throughout the season have been teneral or juvenile. The fact that occasional old females have been taken far away from the ponds suggests that they may migrate from the ponds along with the males which commonly do so.

In the foregoing pages no mention has been made of one of the most important factors in the ecology of insects: food. This subject is being studied separately and will be reported upon at a later date.